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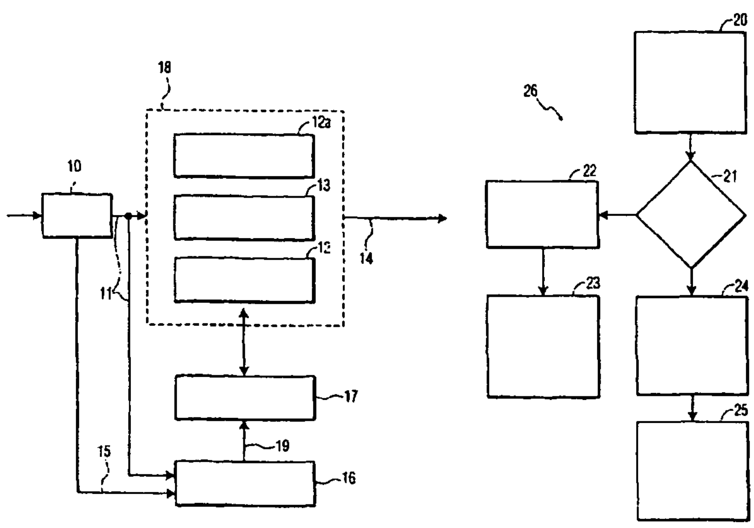
(54) Title: JOINT RESOLUTION OR SHARPNESS ENHANCEMENT AND ARTIFACT REDUCTION FOR CODED DIGITAL VIDEO



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(57) Abstract: The present application is a new approach for jointly controlling resolution or sharpness enhancement and artifact reduction in order to improve picture quality for coded digital video. The present application provides a joint control that is based on a metric, the metric being used to determine which pixel and by how much it is to be enhanced and to determine on which pixel and to what degree to carry out the artifact reduction.

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JOINT RESOLUTION OR SHARPNESS ENHANCEMENT AND ARTIFACT REDUCTION FOR CODED DIGITAL VIDEO

1. Field of the Invention

The present invention is a new approach for joint video enhancement and artifact reduction in order to achieve optimal picture quality for coded digital video. Video enhancement may include resolution enhancement or sharpness enhancement. More particularly, the present invention is a system and method that includes sharpness enhancement or resolution enhancement, artifact reduction, and a joint control to drive both post-processing units. Most particularly, the present invention provides a joint control that is based on a metric, such as the metric provided in the inventor's co-pending patent application entitled "A Unified Metric For Digital Video Processing (UMDVP)", the entire content of which is hereby incorporated by reference as if fully set forth herein, the metric being used to determine which pixel and by how much it is to be enhanced and to determine on which pixel and to what degree to carry out the artifact reduction.

2. Description of the Related Art

Moving Picture Expert Group (MPEG) video compression technology enables many current and emerging products, e.g., DVD players, high definition television decoders, and video conferencing, by requiring less storage and less bandwidth. Compression comes at the expense of a reduction in picture quality due to the introduction of artifacts. It is well known that such lossy compression technology (MPEG-1, MPEG-2, MPEG-4, H.26x, etc.) can cause the introduction of coding artifacts that decrease picture quality of the decoded video. In block-based coding techniques the most frequent artifacts are blockiness and ringing and numerous algorithms have been developed that address reduction of these various artifacts. While the common objective of these algorithms is to reduce the artifacts without decreasing any other desirable feature of the scene content (e.g., image sharpness and fine detail). In reality, the traditional sharpness enhancement

algorithms perform sub-optimally for encoded digital video, often enhancing coding artifacts already present, see inventors' co-pending patent application entitled " System and Method of Sharpness Enhancement for Coded Digital Video," the entire content of which is hereby incorporated by reference as if fully set forth herein.

In another of the inventors' co-pending patent applications entitled "Unified Metric For Digital Video Processing," a metric for digital video processing is defined based on MPEG coding information and local spatial features. This metric determines how much a pixel can be enhanced without boosting coding artifacts. Experiments have shown that sharpness enhancement algorithms alone combined with this metric result in better picture quality than algorithms without it. However, the video still contains coding artifacts, that need to be removed to achieve optimal picture quality.

Usually, in both de-blocking and de-ringing algorithms, the first step is to detect the artifacts, then the next steps apply artifact reduction on the localized area of the image having artifacts. If the artifact detection step is incorrect, resulting picture quality can be worse than before artifact reduction. Therefore, it is crucial to have reliable detection of coding artifacts.

It is very likely that both resolution or sharpness enhancement algorithms and artifact reduction algorithms will co-exist in a system for receipt, storage, and further processing of a priori coded digital video, e.g., MPEG coded video. Current approaches to sharpness enhancement and artifact reduction are performed independently of one another and improvements resulting from one can impact the other negatively thereby decreasing picture quality.

Thus, there is a need for a joint approach to resolution or sharpness enhancement (SE) and artifact reduction (AR) that identifies/differentiates coding artifacts and local fine details. The resolution enhancement consists of a scaling function and a sharpness enhancement algorithm. The present invention deals only with the sharpness enhancement

part of the resolution enhancement. The present invention is a unified approach for joint sharpness enhancement and artifact reduction that achieves optimal picture quality for coded digital video.

Once a metric, such as UMDVP, identifies which pixel is a good candidate for enhancement and on which artifact removal has to be applied, the present invention provides a control to efficiently and reliably drive both SE and AR. In one embodiment, the present invention employs a metric to characterize the pixel containing coding artifacts such as blockiness and ringing. Then, based on the metric the control determines which and how many neighboring pixels are to be involved in AR without blurring relevant features such as edges and fine details in the vicinity of the original pixel. In addition, based on the metric the present invention determines how "aggressively" AR should be applied to a certain region or an individual pixel.

In areas that are "artifact-free", the joint control of the present invention based on a unified metric can drive SE to enhance edges and textures in these areas such that the amount of enhancement applied can be controlled to achieve optimal picture quality.

FIG. 1 illustrates a functional view of a post-processing system for a jointly controlling resolution or sharpness enhancement (SE) and artifact reduction (AR) of decoded video.

FIG. 2 illustrates a flow diagram of the control level of the post-processing method of the present invention.

FIG. 3 illustrates a flow diagram of an algorithm level UMDVP-controlled deringing of the luminance signal.

FIG. 4 illustrates the neighborhood of UMDVP values of point (i,j).

FIG. 5 illustrates a flow diagram of an algorithm level UMDVP-controlled deringing of the chrominance signal.

Referring now to FIG. 1, an MPEG-2 decoder 10 decodes an input video signal and the decoded video signal 11 is input to the post-processing unit 18. The post-processing unit 18 comprises a sharpness enhancement module 12 or resolution enhancement module 12a, and an artifact reduction module 13.

The artifact reduction module 13 comprises at least one algorithm selected from the group comprising e.g. de-blocking , de-ringing etc..

A control module 17 uses a metric 19 to jointly control the application of post-processing to the decoded video signal 11 by the sharpness enhancement module 12 and the artifact reduction module 13. The control module 17 receives the metric 19 from a metric calculation module 16. The MPEG-2 decoder 10 sends coding information 15 as well the decoded video signal 11 to the metric calculation module 16. The output of the system is the post-processed video 14.

Unified Metric for Digital Video Processing

In a preferred embodiment, the metric calculation module 16 calculates "A Unified Metric for Digital Video Processing" (UMDVP), as described in the inventors' co-pending application of the same title. From the block-based coding information 15, the UMDVP metric is calculated and reflects the local picture quality of the MPEG-2 encoded video. The UMDVP is determined based on such block-based coding information as the quantization scale, number of bits spent to code a block, and picture type (I, P or B). Such coding information is obtained from the MPEG-2 bitstream for little computational cost. The coding information is sent by the decoder to the metric calculation module . The metric calculation module 16 can adapt the UMDVP to the local scene contents using local spatial features such as local variance. The spatial features are used to refine the metric to a pixel-based value to further improve the performance of the joint post-processing unit 18.

The values of the UMDVP metric are in the range of [-1,1]. The lower the UMDVP value, the more likely the pixel is to have coding artifacts. In general, high

positive UMDVP values indicate that the pixels should be sharpened and excluded from artifact reduction. The control module 17 receives the UMDVP metric 19 and uses this metric 19 to jointly control the sharpness enhancement module 12 and the artifact reduction module 13 of the post-processing unit 18. The value of metric 19 determines which of the post-processing modules is turned on, and in what order. For example, if the UMDVP metric 19 is smaller than a pre-determined threshold, *VP_THRED*, sharpness enhancement module 12 is turned off and artifact reduction module 18 is turned on and if UMDVP metric is greater than or equal to the threshold *VP_THRED* the artifact reduction module 18 is turned off and the sharpness enhancement module 12 is turned on. It is not necessary to turn off one function completely. For example, if it is determined that AR has performed well at a region with artifacts, SE can be enabled to improve the sharpness in that region)

While the UMDVP metric can indicate whether or to what degree to apply artifact reduction to a pixel, this metric does not provide a means to distinguish between different coding artifacts, such as blockiness or ringing. Thus, it is up to the artifact reduction module 13, once activated by the control module 17, to determine how to use the UMDVP metric to achieve a higher performance. For example, the value of the UMDVP metric 19 determines how "aggressively" artifact reduction or sharpness enhancement should be performed. The lower the value of the UMDVP metric below the value of *VP_THRED* the more artifact reduction the control unit 17 directs the artifact reduction unit 13 to perform. Otherwise, the larger the value of UMDVP is above *VP_THRED* the more enhancement the sharpness enhancement module 12 is directed to perform by the control unit 17.

The use of a metric in conjunction with *VP_THRED* is illustrated in FIG. 2. The metric M = UMDVP is calculated from block-based coding information at step 20. The difference between the pre-determined threshold, *VP_THRED*, and the calculated metric M is determined at step 21 using the equation

AMT = M - *VP_THRED*

The value of AMT indicates how aggressively post-processing should be applied, i.e., in direct proportion to the absolute value of AMT. When AMT is positive, artifact reduction is turned off at step 24 and enhancement is turned on at step 25 with the amount of enhancement applied over a base level being in proportion to AMT, i.e., the aggressiveness of the enhancement. If AMT is not positive, i.e., 0 or negative, enhancement is turned off at step 22 and artifact reduction is turned on at step 23. Since the lower the value of M for a given block the more likely it is that a block has artifacts, more aggressive artifact reduction is performed when it is performed in proportion to |AMT|.

Artifact Reduction Algorithms

Many types of artifacts can be introduced by lossy encoding of a video signal and can be reduced using corresponding algorithms during post-processing by the post-processing unit 18. A metric, e.g., UMDVP, can be used to control when, where and how much post-processing is accomplished by these algorithms.

Two types of artifacts that commonly occur in coded video streams are blockiness and ringing. Blockiness manifests itself as visible discontinuities at block boundaries due to the independent coding of adjacent blocks. Ringing is most evident along high contrast edges in areas of generally smooth texture and appears as ripples extending outwards from the edge. Ringing is caused by abrupt truncation of high frequency DCT components, which play significant roles in the representation of an edge.

While blockiness and remedial de-blocking have been widely studied and many de-blocking algorithms have been developed, ringing has drawn less attention. In particular, satisfactory deringing algorithms for large high-contrast high-resolution displays are not present in the prior art and those that due exist are either based on simple spatial filtering resulting in a compromised picture quality, or their computational complexity prevents any implementation in the near-term. However, ringing artifacts can be even visible at higher

bit rates and are exaggerated on such displays as High-definition monitors, and are thus very annoying.

Both de-blocking and de-ringing algorithms can be controlled by the system and method of the present invention.

UMDVP-Controlled Deringing

For purposes of example and not limitation, a deringing algorithm of the artifact reduction module is presented to illustrate how an appropriate metric can be used to control a post-processing algorithm. This deringing algorithm is based on adaptive spatial filtering and employs a metric, such as UMDVP, calculated by the metric calculation unit 16, to determine the location of the filtering (detection), the size of the filter, and which pixels are included or excluded in the filter window. Further, based on the value of the metric, the deringing algorithm adaptively determines how much a filtered pixel can differ from its original values, thus providing a control over the displacement that depends on the strength of the original compression.

Ringing artifacts can occur in the chrominance components, resulting in colors that differ from the surrounding area, and, due to color sub-sampling, may spread through the entire macroblock. This problem is remedied by applying chrominance filtering in a carefully controlled way to prevent any color mismatch.

a. Deringing for the Luminance Component

By way of example and not limitation, a flow of the processing steps for a UMDVP-controlled deringing of the *luminance signal* is illustrated in FIG. 3. Consider a pixel located at position (i,j), where the neighborhood of position (i,j) is defined as illustrated in FIG. 4. At step 31 it is determined whether an isolated "0" UMDVP value is found in a neighborhood of UMDVP values of "1" and if so then UMDVP(i,j) is set to 1, for the pixel at location (i,j) at step 32. A neighborhood size is selected, in a preferred embodiment a 3x3 neighborhood of the pixel to be deringed, and at step 33 it is determined

whether all of the UMDVP values in this neighborhood are less than or equal to "0" or if the pixel is not in a homogeneous neighborhood but has a negative UMDVP value. The condition tested at step 33 prevents performing deringing on isolated points as well as excessive blurring in, e.g., texture areas, where the UMDVP values are a mix of "1"s and "0"s.

If the condition at step 33 is satisfied, luminance values of the pixel are filtered by a first Filtering I at step 35, e.g., a low-pass filter using the chosen window size and which excludes the pixels which differ by more than a given amount, e.g., 10%, from the luminance value of the pixel being deringed. Thus, pixels with significantly different luminance values are excluded so that fine details are not filtered out instead of artifacts. Other types of filtering can be used besides low-pass, see Filtering II discussion which follows.

If the condition at step 33 is not satisfied, luminance values of the pixel are filtered by a second Filtering II step 34, which also performs as a low-pass filter:

$$Y\_filt(i,j) = Y(i,j) - f(UMDVP(i,j)) * hp(i,j)$$

where Y(i,j) is the original luminance value, f(UMDVP(i,j)) is a function of UMDVP(i,j) and hp(i,j) is the high-pass signal. By way of example and not limitation,

$$f(UMDVP(i,j)) = (1-UMDVP(i,j))/a$$

where "a" can be, e.g., 2, 4, 8, ... For "a" = 4 the calculation of hp(i,j) can be accomplished using the following filter kernel:

$$\begin{matrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{matrix}$$

Then, the output of the filter kernel is multiplied by 0.5 to prevent very strong low-pass filtering.

After filtering, at step 36 the original values are replaced by the filtered one based on, for example and not in any limiting sense, the following definition of the maximum displacement:

Max_displ = PAR1 + PAR2 if pixel (i,j) belongs to homogenous area

Max_displ=abs(UMDVP)*PAR1 +PAR2, if not homogenous and

UMDVP(i,j) <=0

Max_displ = PAR2, otherwise,

where, for example, PAR1 =30, PAR2 = 10.

If the absolute difference of the original luminance value and the filtered value is greater than the Max_displ calculated above, then either the original value will be kept or shifted only by the Max_displ at step 36, that is, it is set to *f*(Y(i,j), Y_filt(i,j), Max_displ). b.

Deringing of the Chrominance Components

By way of example and not limitation, a flow of the processing steps for a UMDVP-controlled deringing of the *chrominance signal* is illustrated in FIG. 5. Consider a pixel located at position (i,j). At step 51 it is determined whether an isolated "0" UMDVP value is found in a neighborhood of UMDVP values of "1" and if so then UMDVP(i,j) is set to 1 for the pixel at location (i,j) at step 52. A neighborhood size is selected, in a preferred embodiment a 7x7 neighborhood of the pixel to be deringed, and at step 53 it is determined whether pixel(i,j) belongs to a homogeneous area. The reason a bigger window size is chosen is that in common digital video systems, the chrominance signal is sub-sampled with respect to the luminance signal, e.g., in a 422 color format the chrominance signal is sub-sampled by 2 horizontally.

If the condition at step 53 is satisfied, a low-pass filtering is applied at step 54 to the original chrominance values, i.e., in a 3x5 window to match with a 422 sub-sampling. In the filtering pixels are excluded for which chrominance values differ by more than a given amount, e.g., 10%, from the chrominance value of the pixel being deringed. Thus, pixels with significantly different chrominance values are excluded so that color mismatch is prevented.

After filtering, the original values are replaced by the filtered ones at step 55 based on, for example and not in any limiting sense, the following definition of the maximum displacement for chrominance components:

Max_displ_chrom = (PAR1 + PAR2)/4 if pixel(i,j) is belongs to homogenous area

Max_displ_chrom = (abs(UMDVP) * PAR1 +PAR2)/4, if not homogenous and UMDVP(i,j) <=0

Max_displ_chrom = PAR2/4, otherwise,

where, for example, PAR1 =30, PAR2 = 10.

The max displacement for chrominance components is the same as the one used for luminance, except here it is scaled down by factor of 4 to prevent any color mismatch. The divisor is determined empirically. If the absolute difference of the original chrominance values and the filtered values is greater than the Max_displ_chrom calculated above, then either the original values will be kept or shifted only by the Max_displ_chrom at step 55, that is they are set to f(U(i,j), U_filt(i,j), Max_displ_chrom) and f(V(i,j), V_filt(i,j), Max_displ_chrom).

Sequential Control of Post-Processing

Post-processing using a metric is accomplished serially, in another preferred embodiment. Metric-controlled deringing (AR) followed by metric-controlled resolution

or sharpness enhancement (SE) is one such serial control that is possible using the control 17.

In view of this disclosure the various units and modules described herein can be implemented in either software or hardware or a combination of the two to achieve a desired performance level. Further, the post-processing algorithms and their parameters are included by way of example only and not in any limiting sense. Therefore, the embodiments described are illustrative of the principle of this invention for the use of a metric for the joint control of a plurality of post-processing algorithms as applied to coded digital video and are not intended to limit the invention to the specific embodiments described. In view of this disclosure, those skilled in the art can implement the apparatus comprising a control unit that uses a metric to control a post-processing unit for decoded digital video by determining the type, aggressiveness and order of post-processing algorithm application to the decoded digital video in a wide variety of ways. Further, the types of post-processing algorithms are not limited to those disclosed as examples and the post-processing algorithms themselves can make use of the metric in determining their own processing of the decoded digital video.

CLAIMS:

1. A system for post-processing of decoded digital video, comprising:

a metric calculation unit for calculation of a metric M for determining the type, aggressiveness, and order of application of a plurality of post-processing modules to the decoded digital video, the metric being based on block-based coding information obtained from the decoded digital video;

a post processing unit for improving the quality of the decoded digital video based on the metric M, comprising the plurality of post-processing modules; and

a control unit for controlling the activation of at least one post-processing module, of the plurality of post-processing modules of the post-processing unit, based on the metric M,

wherein, the quality of the decoded digital video is improved by the control unit activating, in order, at least one of the plurality of post-processing modules and the at least one activated post-processing module processing the digital video based on the metric M.

2. The system of claim 1, wherein said plurality of post-processing modules comprises at least one algorithm of each type selected from the group of types consisting of artifact reduction, sharpness enhancement, and resolution enhancement.

3. The system of claim 2, wherein the at least one artifact reduction algorithm comprises at least one of a luminance deringing algorithm based on the metric M and a chrominance deringing algorithm based on the metric M.

4. The system of claim 2, wherein the control unit further comprises a first mechanism that activates the at least one artifact reduction algorithm and turns off the at least one sharpness enhancement algorithm according to the formula:

$$M < VP\_THRED$$

and turns off the at least one artifact reduction algorithm and activates the at least one sharpness enhancement algorithm, otherwise,

wherein *VP_THRED* is a pre-determined threshold and once activated, the algorithm determines how "aggressively" the algorithm is performed based on the value of the M metric.

5. The system of claim 2, wherein the control unit further comprises a second mechanism that determines if the algorithm that was activated performed well and if so activates the algorithm that was turned off.

6. The system of claim 4, wherein the at least one artifact reduction algorithm comprises at least one of a luminance deringing algorithm based on the metric M and a chrominance deringing algorithm based on the metric M.

7. The system of claim 4, wherein the metric M calculated is a unified metric for digital video processing (UMDVP), wherein the values of the UMDVP metric are in the range of [-1,1].

8. The system of claim 7, wherein the at least one artifact reduction algorithm comprises at least one deringing algorithm based on the metric UMDVP.

9. The system of claim 8, wherein isolated zero values of UMDVP in the neighborhood of a pixel at location (i,j) having a UMDVP value of 1, are replaced by 1 to prevent performing the deringing algorithm on an isolated pixel as well as excessive blurring for the neighborhood in which the UMDVP values are a mix of 1s and 0s, wherein a neighborhood is nxn pixels surrounding the pixel being deringed.

10. The system of claim 9, wherein:

the deringing algorithm is a luminance deringing algorithm having at least one filter, the at least one filter being adapted to -

a. select a luminance filter for the pixel at location (i,j) using a 3x3 neighborhood size, according to whether the UMDVP values indicate that the 3x3 neighborhood of the pixel at location (i,j) is homogeneous and the pixel at location (i,j) has a negative UMDVP value,

b. with the selected filter, calculate a filtered value for the luminance at pixel (i,j) based on the UMDVP value at (i,j) , and

c. calculate a maximum displacement of the filtered luminance value at location (i,j) from the original luminance values at location (i,j) based at least in part on the UMDVP value at (i,j), and

d. replace the original luminance values at location (i,j) by the filtered one based on a function of the calculated maximum displacement of the filtered value from the original value.

11. The system of claim 10, wherein the filter value for the luminance at pixel(i,j) is

$$Y\_filt(i,j) = Y(i,j) - f(UMDVP(i,j)) * hp(i,j)$$

wherein, Y(i,j) is the original luminance value, f(UMDVP(i,j)) is a function of UMDVP(i,j) and hp(i,j) is a high-pass signal.

12. The system of claim 11, wherein

$$f(\text{UMDVP}(i,j)) = (1\text{-UMDVP}(i,j))/a$$

where "a" is selected from the sequence $2^n = 2, 4, 8, \ldots$ for n a positive integer. 13. The system of claim 12, wherein for "a" = 4 the calculation of hp(i,j) is accomplished using the following filter kernel:

$$\begin{matrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{matrix}$$

and the output of the filter kernel is multiplied by 0.5 to prevent very strong low-pass filtering.

14. The system of claim 10, wherein the function of the calculated maximum displacement is

a. Max_displ = PAR1 + PAR2 if pixel (i,j) belongs to homogenous area,

b. Max_displ = abs(UMDVP) * PAR1 +PAR2, if not homogenous and UMDVP(i,j) <=0,

c. Max_displ = PAR2, otherwise, wherein PAR1 and PAR2 are pre-determined parameters,

d. if the absolute difference of the original luminance value and the filtered value is greater than the calculated Max_displ, then either the original value will be kept or shifted only by the Max_displ

Y_filt(i,j) = Y

or Y_filt = Y+Max_displ

or Y_filt = Y-Max_displ.

15. The system of claim 15, wherein PAR1 =30 and PAR2 = 10.

16. The system of claim 9, wherein:

the deringing algorithm is a chrominance deringing algorithm having a filter, the filter being adapted to -

a. filter chrominance values at pixel (i,j) using a 3x5 neighborhood size, when the UMDVP values indicate that a 7x7 neighborhood of the pixel (i,j) is homogeneous,

b. calculate filtered values for the chrominance at pixel (i,j) based on low-pass filtering ,

c. calculate a maximum displacement of the filtered chrominance values at location (i,j) from the original chrominance values at location (i,j) based at least in part on the UMDVP value at (i,j), and

d. replace the original chrominance values at location (i,j) by the filtered ones based on a function of the calculated maximum displacement of the filtered values from the original values.

17. The system of claim 1, wherein said control unit serially activates said post-processing modules of the plurality of post-processing modules of the post-processing unit, based on said metric.

18 The system of claim 17, wherein said post-processing modules comprise at least at least one artifact reduction algorithm and at least one of a sharpness and resolution enhancement algorithm.

19. A method for post-processing of decoded digital video to improve the quality of the decoded digital video, comprising the steps of:

providing a mechanism that calculates a metric M for determining the type, aggressiveness, and order of application of a plurality of post-processing modules to the decoded digital video, the metric being based on block-based coding information;

providing a mechanism comprising a plurality of post-processing modules that post-process the decoded digital signal to improve the quality of the decoded digital video based on said metric;

providing a control unit for the activation of at least one post-processing module, of the plurality of post-processing modules of the post-processing unit, based on said metric,

calculating a metric M for controlling post-processing of each pixel of the block based on the metric; and

activating at least one of the plurality of provided post-processing modules whose selection and processing is based on the calculated metric M to improve the quality of the decoded digital.

20. The method of claim 19, wherein said step of providing a plurality of post-processing units comprises the step of providing at least one artifact reduction algorithm and at least one of a sharpness and resolution enhancement algorithm.

21. The method of claim 20, wherein the step of providing at least one artifact reduction algorithm further comprises the step of providing at least one luminance deringing algorithm based on the metric M and at least one chrominance deringing algorithm based on the metric M.

22. The method of claim 20, wherein the activating step further comprises the steps of:

providing a pre-determined threshold, *VP_THRED*;

if M < *VP_THRED*, performing the substeps of -

a. turning off the at least one sharpness enhancement algorithm, and

b. activating the at least one artifact reduction algorithm,

if M >= *VP_THRED*, performing the substeps of -

c. turning off the at least one artifact reduction algorithm, and

d. activating the at least one sharpness enhancement algorithm,

determining by the activated algorithm, how aggressively the algorithm is performed based on the value of the metric M.

23. The method of claim 22, wherein the step of providing at least one artifact reduction algorithm further comprises the step of providing at least one luminance deringing algorithm based on the metric M and at least one chrominance deringing algorithm based on the metric M.

24. The method of claim 23, wherein the step of calculating the metric M is further based on a mechanism that calculates M as a unified metric for digital video processing (UMDVP),

wherein, the values of the UMDVP metric are in the range of [-1,1].

25. A program product stored on a recordable medium for performing post-processing of a decoded digital video, comprising:

means for post-processing the decoded digital video based on a calculated metric;

means for calculating a metric, based on block-based coding information obtained from the decoded digital video, for determining the type, aggressiveness, and order of application of the post-processing means to the decoded digital video;

means for controlling the activation and order of activation of the post-processing means using the calculated metric.

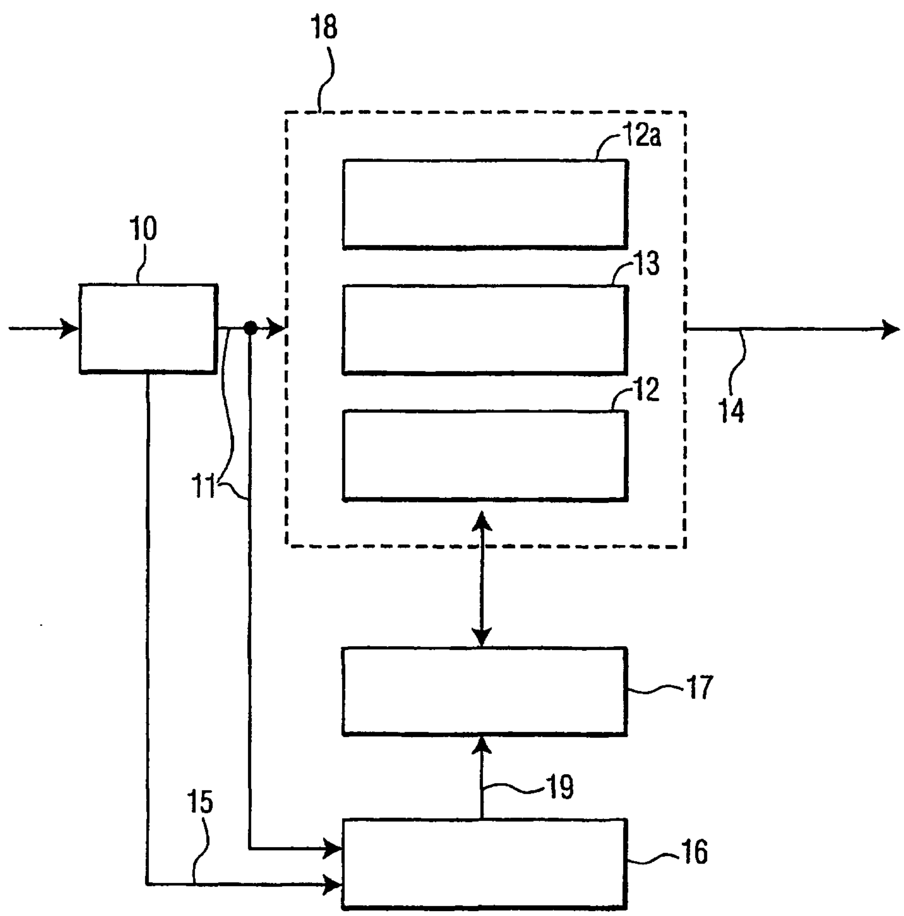

FIG. 1

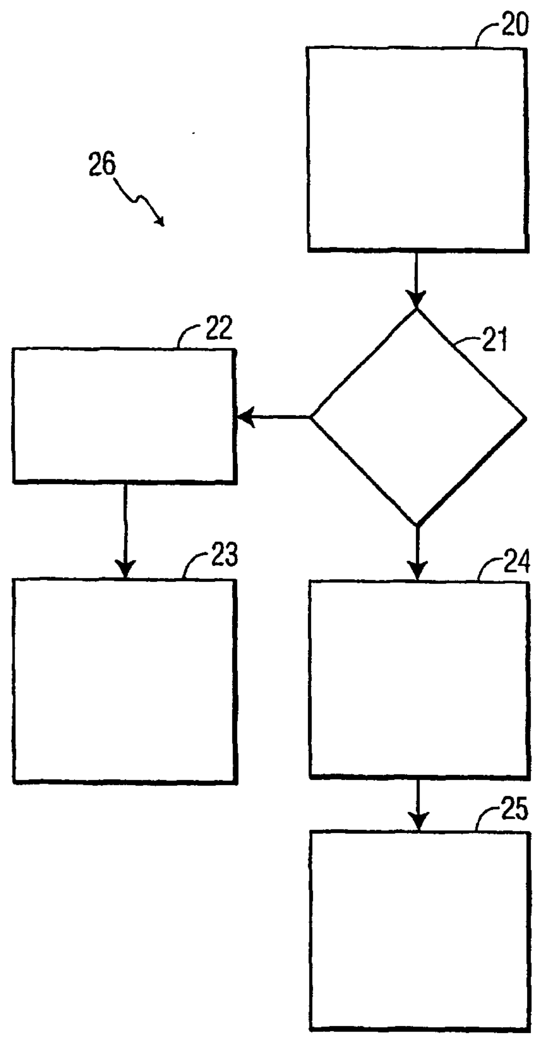

FIG. 2

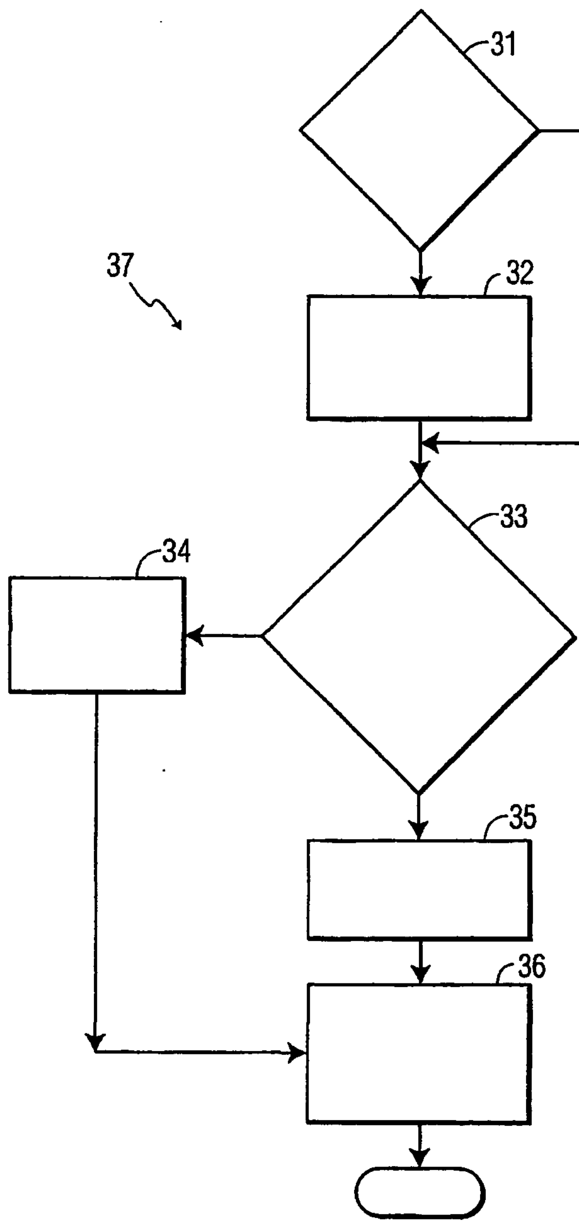

FIG. 3

1 0 1 i, j	1 0 0 1 i, j	1 0 0 1 i, j
1 0 (i, j) 1	1 0 (i, j) 0 1	1 0 0 (i, j) 1
1 0 (i, j) 1	1 0 (i, j) 1	

FIG. 4

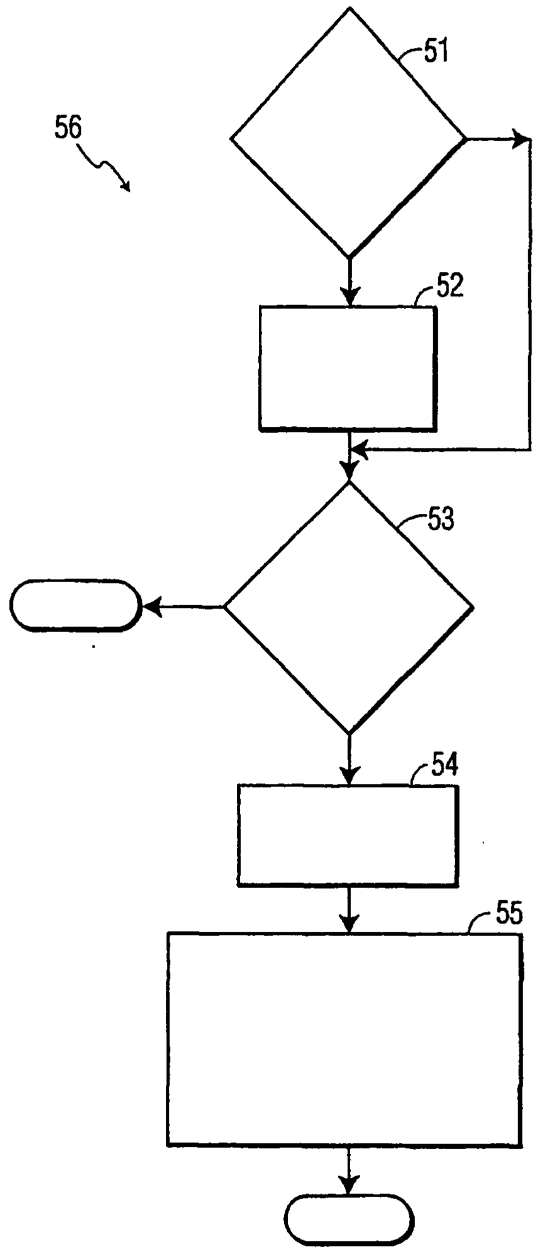

FIG. 5

INTERNATIONAL SEARCH REPORT

Internation   lication No
PCT/IB 03/05536

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/30 G06T5/20 H04N7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ATZORI L ET AL: "A real-time visual postprocessor for MPEG-coded video sequences" SIGNAL PROCESSING. IMAGE COMMUNICATION, ELSEVIER SCIENCE PUBLISHERS, AMSTERDAM, NL, vol. 16, no. 8, May 2001 (2001-05), pages 809-816, XP004249808 ISSN: 0923-5965 abstract page 809, right-hand column, line 7 - line 11 page 810, left-hand column, line 38 - line 42 section 2: The proposed postprocessor section 5: Conclusions figure 1 ----- -/--	1-6, 17-23,25

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 March 2004	12/03/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Sampels, M

INTERNATIONAL SEARCH REPORT

Internation: lication No
PCT/IB 03/05536

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	LEE Y L ET AL: "Loop-filtering and Post-filtering for low Bit-rates Moving Picture Coding" PROCEEDINGS 1999 INTERNATIONAL CONFERENCE ON IMAGE PROCESSING. ICIP'99. KOBE, JAPAN, OCT. 24 - 28, 1999, INTERNATIONAL CONFERENCE ON IMAGE PROCESSING, LOS ALAMITOS, CA, USA, vol. 1 OF 4, 24 October 1999 (1999-10-24), pages 94-98, XP000921740 IEEE, New York, USA ISBN: 0-7803-5468-0 abstract page 94, right-hand column, line 11 - line 21 page 95, left-hand column, line 19 - line 29 page 96, left-hand column, line 3 - line 28 section 3.3: Deringing filter for reducing ringing noise ---	1-6, 17-23,25
A	SEGALL C A ET AL: "Pre- and post-processing algorithms for compressed video enhancement" CONFERENCE RECORD OF THE 34TH ASILOMAR CONFERENCE ON SIGNALS, SYSTEMS & COMPUTERS, vol. 2, 29 October 2000 (2000-10-29), pages 1369-1373, XP010535224 IEEE, New York, USA the whole document ---	1-6, 17-23,25
A	YIBIN YANG ET AL: "A new enhancement method for digital video applications" IEEE TRANSACTIONS ON CONSUMER ELECTRONICS, AUG. 2002, IEEE, USA, vol. 48, no. 3, pages 435-443, XP002272081 ISSN: 0098-3063 the whole document ---	1-6, 17-23,25
A	WO 02 056582 A (KONINKL PHILIPS ELECTRONICS NV) 18 July 2002 (2002-07-18) the whole document ---	1-6, 17-23,25

-/--

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

International Application No
PCT/IB 03/05536

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DERVIAUX C ET AL: "A postprocessing technique for block effect elimination using a perceptual distortion measure" ACOUSTICS, SPEECH, AND SIGNAL PROCESSING, 1997. ICASSP-97., 1997 IEEE INTERNATIONAL CONFERENCE ON MUNICH, GERMANY 21-24 APRIL 1997, LOS ALAMITOS, CA, USA, IEEE COMPUT. SOC, USA, 21 April 1997 (1997-04-21), pages 3001-3004, XP010225788 ISBN: 0-8186-7919-0 the whole document	1-6, 17-23,25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 03/05536

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.: 7-16,24
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 7-16,24

Present claims 7-16 and 24 refer to "a unified metric for digital video processing (UMDVP)". This term has no well-defined meaning in the relevant art and the description fails to define UMDVP. A document "A Unified Metric for Digital Video Processing" cited in the description as a co-pending application and sought to be incorporated by reference (description: page 1, lines 11-13) could not be clearly identified and hence not easily be retrieved, since neither a filing office nor an application number is given. No such document was published before the international filing date of the current application. Therefore no such document can be regarded as part of the disclosure. As far as said claims are concerned, the application does not disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

In the present case, said claims so lack support and the application so lacks disclosure (Article 5 PCT) that a meaningful search over the unclear scope of said claims is impossible.

In order to overcome the above objection, the applicant could at a later stage of the proceedings be requested to provide evidence that the skilled person would be able to define a unified metric for digital video processing from the information contained in the present application as originally filed, by using only his common knowledge and his ordinary skills. It is recalled that textbooks and general technical literature form part of the common general knowledge, but not information which can be obtained only after a comprehensive search. Patent specifications and scientific publications may only be considered to form part of the common general knowledge where an invention is in a field of research so new that the relevant technical knowledge is not yet available from textbooks. If neccessary, an additional search could then be performed by the Examination Authority.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the policy of some offices when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB 03/05536

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 02056582 A	18-07-2002	US 2002131512 A1	19-09-2002
		CN 1416640 T	07-05-2003
		EP 1352515 A1	15-10-2003
		WO 02056582 A1	18-07-2002